

A preliminary study of bryophytes and invertebrates of soil crusts in the Little Desert National Park and surrounds

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Abstract

This study is preliminary to ongoing investigations of soil crusts and associated invertebrates in north-west Victoria, focusing on the Little Desert National Park. Ninety quadrats from nine sites were sampled. Eighteen bryophyte species (nine mosses, nine liverworts) were identified within the quadrats. All invertebrates were from the Phylum Arthropoda. Overall abundance and diversity of invertebrates was low. While sampling in the drier months is valuable for observing the dynamics of soil crusts in this region, a more comprehensive assessment of species diversity is gained by sampling during wetter periods. (*The Victorian Naturalist* 123 (4), 2006, 195-203)

Introduction

Soil generally is considered a precious resource, but what is the value placed on the organisms that comprise soil crusts? Bryophytes, together with lichens, fungi and cyanobacteria (blue-green algae) make up the biological or cryptogamic crusts that play a very important role in protecting soils of the arid and semi-arid zones of Australia, including sensitive rangelands (Eldridge and Tozer 1996; 1997a; 1997b; Hodgins and Rogers 1997, Rosentreter and Eldridge 2002). Biological crusts protect soils from erosion, regulate infiltration of rainfall, provide a suitable microhabitat for germination of seed, photosynthesise when moist, therefore acting as a carbon sink (Moore 1998; Eldridge 2000), and provide food and shelter for invertebrates. In turn, invertebrates play an important role in the regulation of decomposition and nutrient cycling within the crust and soil beneath (Belnap 2001). Recent research (Eldridge 2005) has highlighted the importance of biological crusts as indicators of the effectiveness of landscape management. Conservation of soil crusts requires not only an understanding of the organisms that comprise them, but also of the interactions that occur within them, and how species composition varies geographically.

In Australia, a number of studies have examined the composition of soil crusts in arid and semi-arid areas and rangelands (Eldridge and Tozer 1996; 1997a; Eldridge 1998a; 1998b; Eldridge 2001), the impact of

particular landuse (e.g. grazing, cultivation) on the dynamics of soil crusts (Eldridge *et al.* 2000) and the effect of management activities (e.g. burning off) on these crusts (Eldridge and Tozer 1997a; Hodgins and Rogers 1997). These studies concentrated on areas of western New South Wales, south-western South Australia and Queensland and highlighted the diversity of cryptogamic organisms in soil crusts and the abiotic conditions conducive to development of these crusts. In Victoria, short lists of bryophytes have been included in vegetation studies of Hattah Lakes (Willis 1970) and Wyperfeld (Scott 1982) National Parks, but there are no formal systematic studies of soil crust bryophyte species, the invertebrates that inhabit them, or studies focusing on the dynamics of soil crusts.

The objectives of this preliminary study were to record the composition and abundance of soil crust bryophytes and document the invertebrate fauna inhabiting these crusts in the semi-arid zones of north-western Victoria, in particular the Little Desert National Park (LDNP), Little Desert Lodge, North Goroke State Forest and Jane Duff Reserve.

Methods

Study area

The Little Desert National Park is located in the Wimmera 375 km north-west of Melbourne. The area is described as semi-arid with mean daily maximum summer

temperatures ranging from 28 to 30 °C and mean maximum winter daily temperatures ranging from 14 to 15 °C (Bureau of Meteorology August 2004). Mean annual rainfall is 415 mm with most of the rainfall occurring from May to October (Bureau of Meteorology August 2004). The Wimmera plains were originally covered by woodlands of Yellow Gum, Buloke and Black and Grey Box with large expanses of grassland between the woodlands (Land Conservation Council 1985). Since European settlement most of the natural vegetation has been cleared for agriculture and the LDNP is all that remains of the original vegetation. The national park began as a small reserve for the protection of the Malleefowl (National Parks Service 1996). In the late 1960s there were plans to further develop the area for agriculture. This proposal met with strong public opposition and in 1968 the area was proclaimed a national park. The LDNP has expanded over the years, and by 1988 comprised 132 000 ha (National Parks Service 1996). The vegetation of the national park is predominantly

Brown Stringybark *Eucalyptus baxteri*, with large patches of heath and Mallee-broom-bush *Melaleuca uncinata*, particularly in the eastern and central blocks. The western block is almost all brown stringybark with small scattered patches of gum-box-Buloke woodland (consisting of Yellow Gum woodland and Slender Cypress Pine woodland) and Mallee-broom-bush (Land Conservation Council 1985). The LDNP occurs predominantly in what is now referred to as the Wimmera Bioregion (DSE 2006). Part of the western block of the LDNP is also within the Lowan Bioregion (DSE 2006). Ecological Vegetation Classes have been determined for the two bioregions within the LDNP (DSE 2006).

The first fieldtrip in November 2003 surveyed sites in the 'eastern block' of the LDNP and sites within the Little Desert Lodge (Fig. 1). The second fieldtrip conducted in June 2004 surveyed sites in the 'western and central blocks' of the LDNP and in the North Goro State Forest. In this study, a total of nine sites was examined in detail (Fig. 1). It was originally proposed to

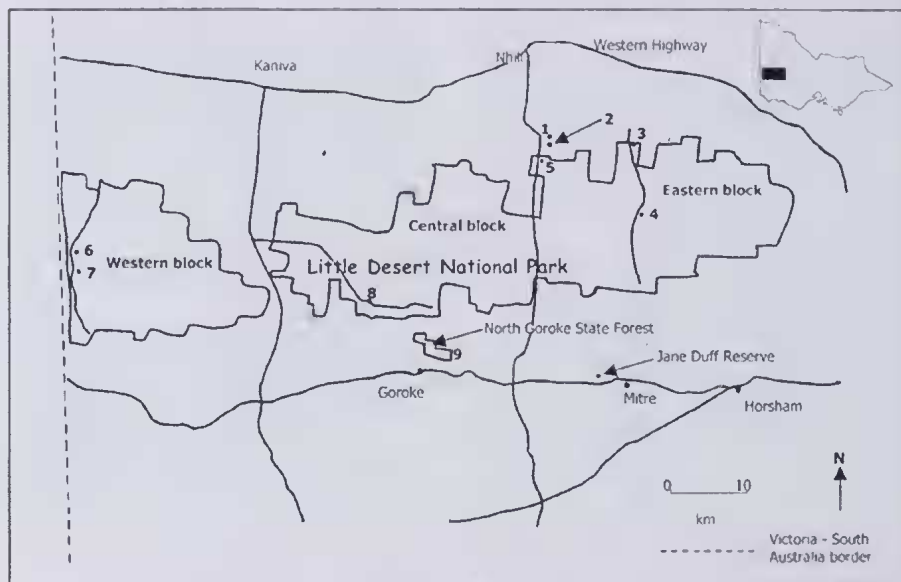


Fig. 1. Location of study sites and predominant vegetation type at each site. 1. Whipmy's Little Desert Lodge Nature Trail 'claypan 1' (Slender Cypress Pine Woodland); 2. Whipmy's Little Desert Lodge Nature Trail 'claypan 2' (Slender Cypress Pine Woodland); 3. Kiata camp ground (Yellow Gum Woodland); 4. Salt Lake Road (Heathland); 5. Stringybark Walk (Slender Cypress Pine Woodland); 6. Mt Moffat Track (Yellow Gum Woodland); 7. Mt Moffat Track, just north of East-West Road (Yellow Gum Woodland); 8. Southern end of Sambell's Track (Yellow Gum Woodland); 9. North Goro State Forest (Yellow Gum Woodland).

sample along transects in diverse vegetation types within the national park, but once in the field it became evident that sites which solely consisted of sandy soils supported little or no soil crusts. Any bryophytes present were restricted to the base of shrubs. Therefore, sampling took place in heathland and in woodlands dominated by Slender Cypress Pine *Callitris gracilis* R.Baker (Fig. 2a) or Yellow Gum *Eucalyptus leu-*

coxylon F.Muell. subsp. *leucoxylon* (Fig. 2b). At each of these sites there was some clay component in the soil. The Jane Duff Reserve, 5 km west of Mitre, was visited en route to the national park.

Data collection

A transect (100 m) was set out at each site. Soil crust bryophyte and lichen species were sampled from 30 x 30 cm quadrats, at 10 m intervals along the tran-



Fig. 2 a, Slender Cypress Pine *Callitris gracilis*, b, Yellow Gum Woodland *Eucalyptus leucoxylon* subsp. *leucoxylon*.

sect. Soil surface features are important as they are indicative of the likelihood of soil crust formation. Biotic and abiotic aspects were recorded for each quadrat along a transect, including characteristics of soil surface morphology e.g. slope within a quadrat, surface microtopography and crust coherence (see Eldridge and Tozer 1997). Within each quadrat the vascular plant cover and leaf litter cover were estimated. The percentage total soil crust cover within the quadrat was then estimated together with the proportion of the algal, bryophyte and lichen components. Small samples of mosses and liverworts were taken to confirm identification. Some collections of the liverwort *Riccia* were fertile. Their spores were examined with a scanning electron microscope (SEM) because the microscopic structure of spores assists in the identification of these plants. The relationship between the suite of soil crust species and vegetation type, leaf litter cover, topography, soil type and associated water retention will be reported elsewhere.

Soil crust samples (10 x 10 x 2 cm deep) were collected from quadrats along each transect and the macro-invertebrate fauna extracted in the laboratory using Tullgren funnels (Gullan and Cranston 2000). In the first fieldtrip, soil crust samples were taken from four quadrats per transect, but as this yielded a low number of invertebrates, five quadrats were sampled along each transect during the June 2004 sampling period. After the invertebrates were extracted, any mosses and liverworts present were identified.

Soil from the November 2003 crust samples was potted out in small sterile pots filled with sterile coarse sand to determine whether spores or asexual propagules of mosses and liverworts were resting in the soil. The pots were placed in ambient light and temperature, watered regularly with distilled water and covered with a plastic sheet to avoid contamination.

Taxonomic nomenclature follows Streimann and Klazenga (2002) for mosses, and McCarthy (2003) for liverworts.

Results

Crust floristics

Eighteen bryophyte species (nine mosses and nine liverworts) representing 11 families

Table 1. Bryophytes recorded within quadrats in the Little Desert National Park, Little Desert Lodge and North Goroke State Forest Victoria, Australia.

Taxa

Mosses

Bryaceae

Rosulabryum billardiarei (Schwägr.)

J.R.Spence*

Rosulabryum campylotheicum (Taylor)

J.R.Spence

Ditrichaceae

Eccremidium sp.

Gigaspurmaceae

Gigaspurm repens (Hook.) Lindb.

Leucobryaceae

Campylopus introflexus (Hedw.) Brid.

Polytrichaceae

Polytrichum juniperinum Hedw.

Pottiaceae

Barbula calycina Schwägr.

Barbula crinita Schultz.

Didymodon torquatus (Taylor) Catches.

Torula antarctica (Hampe) Wilson

Triquetrella papillata (Hook.f. and Wilson)

Broth.

Splachnaceae

Tayloria octoblepharum (Hook.) Mitt.*

Liverworts

Aerobolaceae

Enigmella thallina G.A.M.Scott and

K.G.Beckm.

Lethocolea pansa (Taylor) G.A.M.Scott and

K.G. Beckm.

Arnelliaceae

Gongylanthus scariosus (Lehm.) Steph.

Aytoniaceae

Asterella drummondii (Hook.f. and Taylor)

R.M.Schust. ex D.G.Long

Asterella sp.

Fossombroniaceae

Fossombronia intestinalis Taylor

Fossombronia sp.

Ricciaceae

Riccia papulosa (Steph.) Steph.

Riccia sp.

* Recorded at study sites, but not in quadrats.

were identified (Table 1) from 90 quadrats sampled from nine sites. A further two moss species *Rosulabryum billardiarei* and *Tayloria octoblepharum* were recorded in the vicinity of some of the quadrats. Of the 12 moss taxa, five were from the family Pottiaceae and two from the family Bryaceae. The predominant liverworts recorded were the thallose genera *Asterella* and *Riccia* and the leafy species, *Lethocolea pansa* and *Fossombronia* (Table 1). The Jane Duff Reserve proved rich in *Riccia*

with three species being recorded, *R. cavenosa*, *R. cristallina* and *R. multifida*.

Two mosses, *Fissidens* sp. and *Funaria* sp., that were not recorded in the quadrats grew in the pots from soil samples collected in November 2003.

The impact of season on the percentage of soil crust cover and the contribution particular cryptogams made to crust cover is depicted in Fig. 3. Sampling in June 2004, after substantial rainfall, showed that algae and liverworts, particularly *Asterella* sp., *Fossombronina* sp. and *Lethocolea pansa* formed the predominant components of the soil crusts (Figs. 4d and 5b). In contrast, crusts sampled during the dry period of November 2003 consisted mainly of mosses (Fig. 3).

Invertebrates

All invertebrates collected in this study were from the Phylum Arthropoda. Increased abundance and activity of invertebrates was noted in the June 2004 sampling period. They were observed crawling over the soil crusts, whereas none was observed in the drier conditions in June 2003. No difference in either abundance or diversity of extracted macro-invertebrates was found between the two sampling periods, with the exception of the insect order Collembola (springtails). The majority of arthropods extracted were mites and springtails (Table 2). Only a small number of ants were extracted from the soil crusts, but our field observations suggest that ants are present at most sites but appeared to be moving across soil crusts, between patches of shrub and litter cover, rather than inhabiting the areas of soil crusts. Eight ant species were recorded moving across transects: *Anonychomyrma* sp., *Iridomyrmex* sp. (meat ant), *Camponotus* sp., *Doleromyrma* sp., *Pheidole* sp. 1, *Pheidole* sp. 2, *Rhytidoponera* sp., and *Tapinoma* sp. In the June 2004 sampling period, there were Diptera, Coleoptera and Lepidoptera larvae in the crust samples.

Discussion

The majority of bryophytes recorded in this study also have been documented in other soil crust studies (Eldridge and Tozer 1996; 1997a; 1997b; Eldridge *et al.* 2000; Thompson and Eldridge 2005). The liver-

Table 2. Invertebrates recorded in soil crust within the Little Desert National Park, Little Desert Nature Lodge and North Goroke State forest, Victoria, Australia.

Order	Morphospecies collected	
	Nov 2003	Jun 2004
Araneae	-	1
Acari	6	9
Hymenoptera	1	2
Coleoptera (larvae)	-	2
Lepidoptera (larvae)	-	1
Diptera (larvae)	-	1
Hemiptera	1	-
Blattodea	1	-
Collembola	1	5
Total	10	21

worts *Gongylanthus scariosus*, *Lethocolea pansa* and *Riccia multifida* have not been documented in previous soil crust studies. Differences between the suite of species recorded can be attributed to vegetation communities, soil types, level of disturbance (Eldridge and Tozer 1996; 1997a; Hodgins and Rogers 1997) and sampling season. Also, because of the small size and ephemeral nature of many soil crust bryophytes, taxa can be overlooked. In this study, the season in which surveys were conducted influenced the taxa recorded and, in particular, their relative abundance. Substantial rainfall in early winter (June 2004) influenced the dynamics of the soil crust cover at the study sites, and the ephemeral nature of liverworts became quite apparent. There had been heavy rainfall in the weeks prior to this trip and liverworts formed one of the predominant components of the soil crusts. In the November 2003 fieldtrip, much of the liverwort biomass was not evident, being in a dormant summer phase and nearly impossible to detect, or resting in the soil as either spores or asexual propagules, which produced new plants with the onset of rain (Fig. 5b). The growth of liverworts from soil collected in November 2003 is evidence that the soil does act as a diaspore bank. In June 2004, gemmae were detected amongst the leaves of the liverwort *Lethocolea pansa* indicating a strategy in this species of producing many asexual propagules at the beginning of the growing season, prior to the production of gametangia (male and

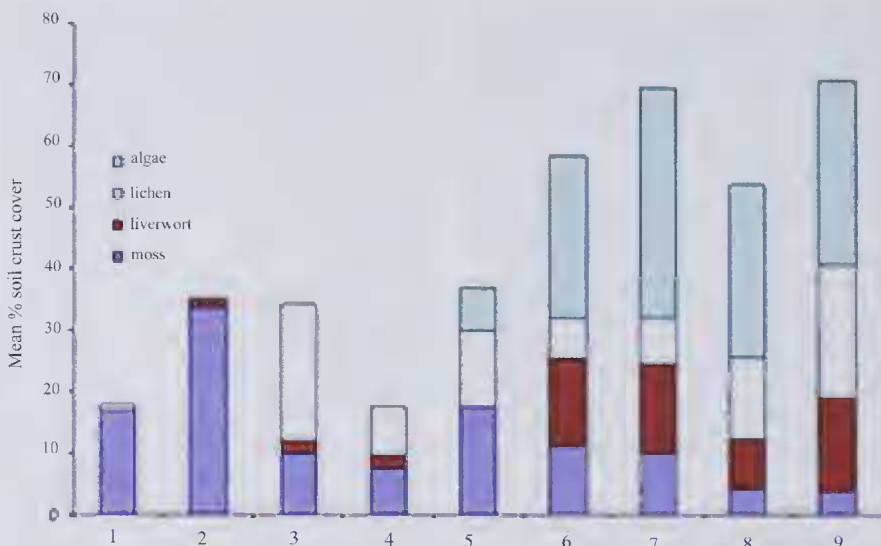


Fig. 3. Mean percentage cover of moss, liverwort, lichen and algae in soil crusts at sites surveyed in the Little Desert National Park, Little Desert Lodge and North Goroke State Forest, Victoria.

female sex organs) (Beckmann 1993). It became apparent that once pots were allowed to dry out, some liverwort species e.g. *Fossombronia* sp. and *Lethocolea pansa*, shrivelled and dried very quickly and were difficult to detect on the soil surface. The stems of these perennial species often act as tubers that persist after the extremities have dried and deteriorated and

new growth is initiated once favourable conditions return (Beckmann 1993). In this state, the presence of these plants is difficult to detect and would explain the lower percentage of liverwort crust component in the November 2003 sampling (Fig. 5a). In contrast, the liverworts *Riccia* and *Asterella* were recorded during the November 2003 sampling. These species



Fig. 5 a. Patch of dry cryptogamic crust, November 2003, b. magnified section of soil crust after significant rain, showing growth of ephemeral liverworts *Fossombronia* sp., *Lethocolea pansa* and the moss *Eccremidium* sp., June 2004.



Fig. 4 a. Dry moss cushion, partially inundated with sand, b. moss cushion after rain, c. mosses between patches of foliose lichen, d. algal crust in *Callitris gracilis* woodland.

demonstrated a strategy of desiccation tolerance where plants employed various mechanisms, in this case scales, to facilitate survival of mature plants which rapidly recover after rain. The inrolled thalli (flattened plant body) of these species had protective scales and were visible in some quadrats during the November 2003 sampling. *Gongylanthus scariosus*, *Lethocolea pansa* and *Enigmella thallina* all produce spores in capsules that develop under the soil in elaborated stem tissue (marsupia). These marsupia persist in the soil after the parent plant has shrivelled or decayed (Beckmann and Scott 1989; 1992).

Mosses and lichens also took advantage of the availability of moisture (Fig. 4c). Moss cushions of *Rosulabryum camylotheicum*, *Barbula calycina*, *B. crinita* and *Campylopus introflexus* all showed evidence of new growth. These species possess morphological characteristics (e.g. hyaline (colourless) leaf tips, leaf cell papillae (thickenings on cell wall), twisting and rolling of leaves) (Scott 1982, Eldridge and Tozer 1996) that enable them to tolerate arid and semi-arid environmental conditions. During dry conditions, moss cushions often are partially inundated by sand and brown in colour (Fig. 4a). After significant rain, cushions rehydrate and growth begins (Fig. 4b). Recruitment of new plants was particularly evident in *Eccremidium* sp., which had been recorded in only four quadrats during the November 2003 fieldtrip (Fig. 5b).

The overall abundance and diversity of invertebrates in the soil crusts of the Little Desert was low. This tends to confirm the observation that, as soil crusts are dry and inhospitable for much of the year, there is unlikely to be a suite of invertebrates specifically inhabiting the soil crusts. Rather, invertebrates are making use of the soil crust as a temporary refuge and food resource when the crusts are hydrated and cryptogam coverage is greater. Larvae appear to be from species that lay their eggs and pupate in the soil, and then use the soil crust as habitat. The results from this preliminary study support the conclusions of Whitford (1996) who reviewed studies of soil invertebrates in arid and semi arid regions and noted that total diversity is lower in arid ecosystems.

From these observations it is recommended that future work on the study of soil crusts involve sampling during the wetter months to attain a more accurate picture of the contribution of the various groups that make up soil crusts. However, surveying overall crust cover in the drier months is valuable in determining which species are more tolerant to desiccation and, to observe the dynamic nature of the soil crusts.

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A pictorial representation of peristomal architecture

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Abstract

The terminology associated with the use of peristomes in the identification and classification of mosses is cumbersome and difficult to understand. This paper provides a pictorial explanation of peristomal architecture with its associated terminology, such as nematodontous and arthrodontous peristomes, and the division of the latter into diplolepidicous and haplolepidicous peristomes. (*The Victorian Naturalist* **123** (4), 2006, 203-211)

The moss plant normally seen and recognised is referred to as a gametophyte as it produces the gametes, i.e. egg and sperm. When the sperm fertilizes the egg a sporophyte develops. The sporophyte is ephemeral and essentially remains dependent on its gametophyte parent (Fig. 1), i.e. nutrients are obtained from the gametophyte parent through the basal foot of a stalk-like structure (the seta) that remains embedded within the parental gametophyte tissue. A spore capsule terminates this seta (Fig. 1).

Many mosses have one or more rings of teeth around the mouth of the capsule (Fig. 2). The teeth collectively are referred to as the peristome (Fig. 1) and are protected by an operculum or lid (Fig. 1), which falls off when the spores are mature. However, not all mosses have peristomes.

The outer ring of teeth (exostome) in double peristomes (Fig. 2) may exhibit

hygroscopic movement in response to changes in humidity by bending backwards and forwards (Proctor 1984). The movement provides a gentle catapulting action for launching spores a short distance into the air, where they may be caught by a gentle breeze and dispersed to an environment suitable for germination. Subsequent to germination, spores will develop into another gametophyte generation. Hygroscopic movement of the exostome may be particularly relevant in closed forest situations where opportunities for air transport of spores needs to be maximized. The inner ring of teeth (endostome) (Fig. 2) may regulate spore dispersal by gradually sifting the spores.

As spore dispersal mechanisms in mosses, peristomes are specialised, intricate and architecturally elaborate. Adaptive trends of morphological characters have resulted